UDC 551.575.11:551.558.1:551.507.362.2(084.1)(285:71/73)"1971.01.30/31"

# PICTURE OF THE MONTH

# "Steam Devils" Over Lake Michigan During a January Arctic Outbreak[1]

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January 1971 was one of the colder winter months of this century in Wisconsin, and, because Lake Michigan remained largely ice-free, there were many spectacular manifestations of the Great Lakes influence upon mesoscale meteorological conditions such as snow squalls. The upcoming (1972–73) International Field Year for the Great Lakes (IFYGL) will, among other things, be concerned with the various aspects of air-water interaction during winter from both the theoretical and observational viewpoints. In light of the recent interest in small-scale atmospheric vortexes, such as the waterspout studies of Golden (1971) and the dust devil investigations of Kaimal and Businger (1970), we would like to suggest an additional phenomenon for possible consideration by IFYGL investigators—the "steam devil".

Figure 1 shows several well-developed steam devils a few miles off the Milwaukee shoreline of Lake Michigan. The period Jan. 30–31, 1971 was intensely cold in Milwaukee, the highest temperature reaching only −6°F with west-northwest winds frequently gusting to 40 mi/hr. Lake snow squalls were present in excelsis along the lee shores of all the Great Lakes. But most interesting was the view from the *upwind* shoreline (fig. 1). During both days, one could see the typical shallow, dense steam fog near the lake surface (water temperature 33°F) and the cumulus clouds building a few miles offshore. What was unusual were the numerous distinct fingers or columns of vapor swirling out of the steam fog layer directly into the overlying cumulus clouds. It is estimated that they were

[1] Contribution No. 61 of the Center for Great Lakes Studies, the University of Wisconsin at Milwaukee

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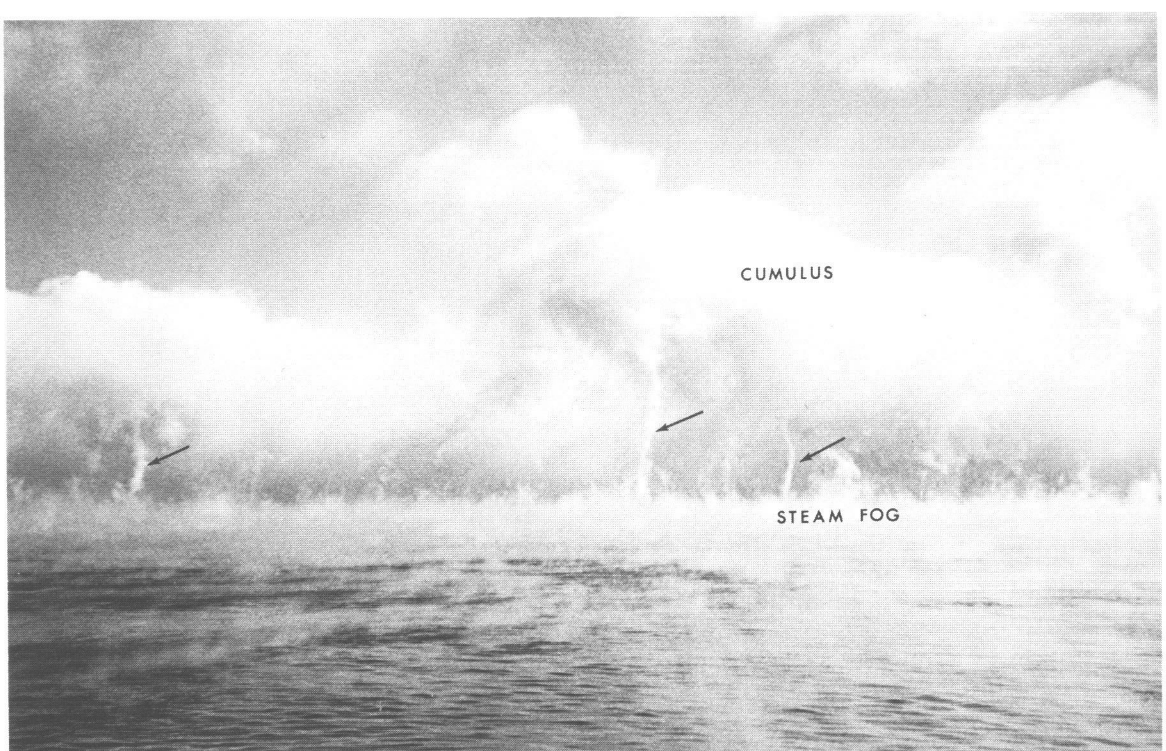


FIGURE 1.—View looking east from Milwaukee shoreline at 1505 CST, Jan. 31, 1971, showing steam devils rising out of general steam fog near the lake surface into the low cumulus cloud bases. The air temperature at this time was −6°F, the lake water surface temperature was 33°F.

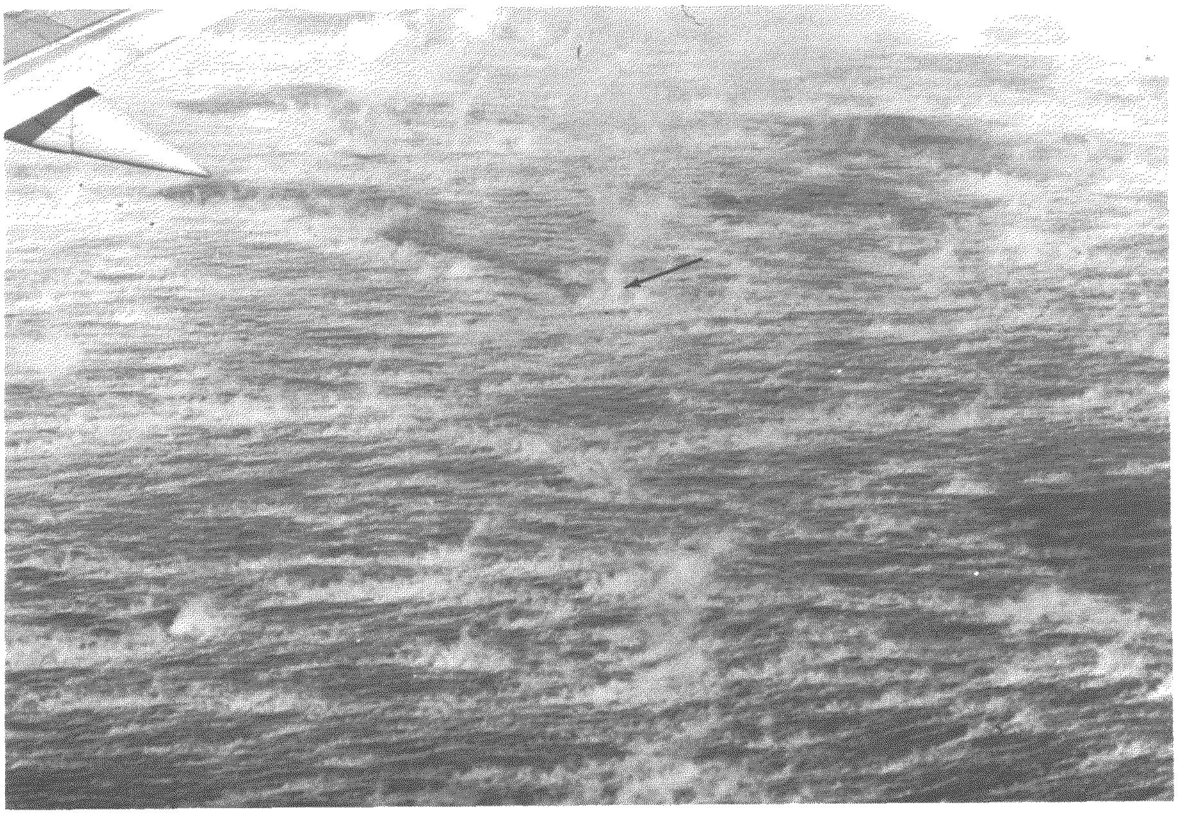

FIGURE 2.—View from 4,000 ft above the lake, looking north-northeast at 1215 CST, Jan. 30, 1971, from a point about 20 n.mi. southeast of the Milwaukee shoreline. Arrows point toward the more prominent steam devils, roughly calculated to be 1,500 ft high.

50–200 m in diameter, traveled more or less with the wind, were nearly vertical, and showed a slow but distinct rotation (mostly cyclonic) of up to several revolutions per minute. The steam devils tended to be rather short lived, the longest surviving perhaps for 3 or 4 min.

An even more interesting view of the same phenomena was taken from a commercial airliner on Jan. 30, 1971. Figure 2 is a view from about 4,000 ft above lake level some 20 n.mi. southeast of Milwaukee looking to the north-northeast at 1215 CST. Visible are small cumulus (which were forming further offshore on this day), plus the steam devils and a highly patterned effect on the surface steam fog. It definitely appears that there were quasi-hexagonal cells elongated along the surface wind direction, the largest steam devils being present at the vertexes of the hexagons. Robert W. Pease, of the University of California at Riverside, who took this picture, estimated the height of the tallest steam devil (arrow) to be approximately 1,500 ft by using photogrammetric techniques. Figures 3 and 4 are satellite views of this area on the 2 days in question.

Earlier this same winter, time lapse films of the lake under similar conditions, taken from atop a tall building in Milwaukee, showed a similar patterned effect to the steam fog. The steam devils were clearly seen to be areas of condensate rising from the surface directly to cloud base, although on that day no rotation was apparent.

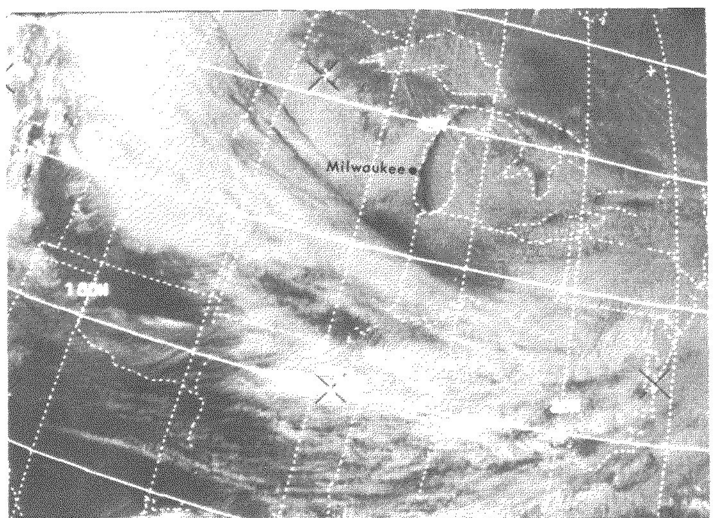


FIGURE 3.—ITOS 1 view, pass 4658, showing Great Lakes area at 1456 CST, Jan. 30, 1971.

The literature has several references to possibly related phenomena. Falconer et al. (1964) show a picture similar to ours over Lake Ontario. In a review of papers on sea smoke and steam fog, Saunders (1964) quotes several authors whose observations suggest similar structures. Lenshow (1965) shows a picture of what appears to be a distinct waterspout over Lake Michigan during a period of extreme cold-air advection.

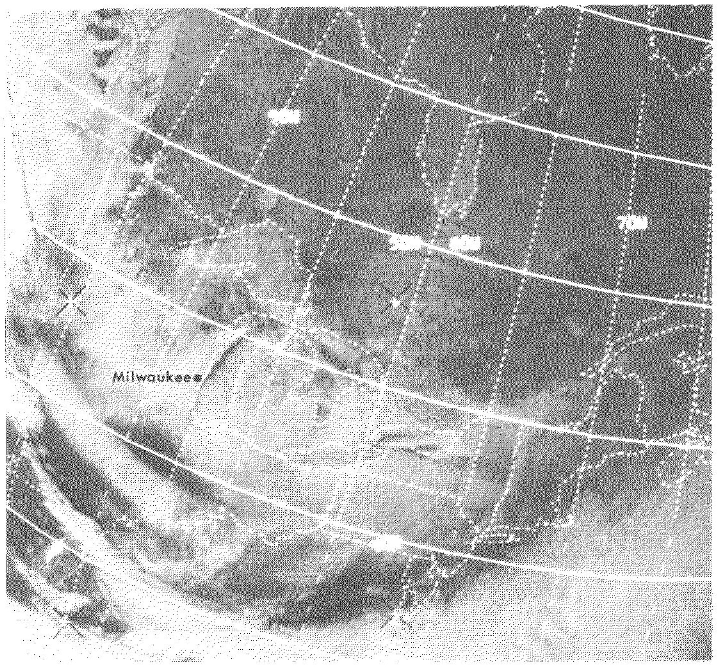


FIGURE 4.—ITOS 1 view, pass 4670, showing Great Lakes area at 1402 CST, Jan. 31, 1971.

The question arises as to what actually is the structure of this phenomenon. Are we dealing with a phenomenon dynamically related to and as vigorous as the waterspouts which inhabit the Florida Keys region, for example? It seems unlikely. While rotation is apparent, it is quite slow. Perhaps these are much more similar in nature and intensity to the dust devil over land. For this reason, we suggest calling them steam devils rather than waterspouts. However, it is hard to be certain until actual field measurements are made. Although steam fog is commonplace over the lake during periods of cold advection, the fingerlike extensions to cloud level are rare and appear only when winds are quite strong (in excess of 25 mi/hr), though this is not to say they cannot occur without condensate making them visible. The one set of available time lapse films of this phenomenon suggests that steam devils are related to traveling subcloud convective plumes rising out of surface superadiabatic layers as described by Warner and Telford (1967). Although the observational difficulties would be formidable, it seems this phenomenon should merit attention during the IFYGL inasmuch as it may be one of the key factors in our understanding of the intense heat, moisture, and momentum transports that occur over the Great Lakes in winter.

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[*Received September 27, 1971; revised January 19, 1972*]